R. J. BRACHMAN ASSOCIATES, INC.

P. O. BOX 1077 · HAVERTOWN, PENNSYLVANIA 19083 (215) 622-5495

C B U S I

Cartridge Back Up System
for the Commodore 64

Cartridge Image Snapshooter

User Manual

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MICROSPORT · COMPUTER PRODUCTS

CBUS I for the Commodore 64

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CBUS I - CARTRIDGE BACK-UP SYSTEM FOR THE COMMODORE 64

1. Introduction

CBUS stands for Cartridge Back-Up System. CBUS I produces backup copies of cartridges for the Commodore 64. Using CBUS I saves wear and tear on the Commodore 64's expansion connector by tricking the computer into running an image of the cartridge without having the cartridge physically present. Up to 17 cartridges can be stored on a single diskette. With CBUS I, cartridges can be stored out of harm's way rather then cluttering up the work area. CBUS I incorporates a RESET switch allowing you to perform a COLD Start without having to turn the machine off and on again. This permits study of cartridge object code, opening up the possibility of custom modifications.

CBUS I consists of a printed circuit board, and a series of programs for taking a "snapshot" of a cartridge, storing it on disk and loading the cartridge image back into the Commodore 64. The basic procedure for backing up a given cartridge is as follows:

1) determine the classification of the cartridge
2) take a "snapshot" of the cartridge
3) store the "snapshot" on disk or tape
4) modify the "snapshot", if necessary, to form a loadable image
5) save the loadable image on disk
6) add the name of the loadable image to the directory for menu-based loading using DISK/CART-I.

The entire method requires about 10 minutes from taking the snapshot to testing the loadable image. If the cartridge requires extensive modification (many don't), it could take longer. However, once the snapshot is stored on disk, modifications can then be performed without having the cartridge physically present and in a more leisurely fashion. A true cartridge emulator, such as CBUS II can be used to run cartridge images with even the heaviest of copy-protection schemes.

You will need a disk-based monitor such as Jim Butterfield's SUPERMON64 (available on the Commodore Bonus Disk or see COMPUTE! January, 1983 for details), or the Commodore Business Machine's MONITOR#C000 (included in their Macro Assembler Development System), or the MINI-MONITOR available on the deluxe version of CBUS. Cartridge-based monitors such as H.E.S.'s HESMON or Commodore's 64MON are not appropriate since they utilize the cartridge slot required by CBUS I.

Two program listings, MENGEN and DISK/CART-I, are included. These provide all the necessary bookkeeping for disk-based cartridge loading. MENGEN generates a directory file which is used by DISK/CART-I for convenient menu-based loading. Cartridge selection is made via the [CRSR UP/DN] key or joystick (either port) and loading is performed via the [RETURN] key or FIRE button.

The appendices contain some useful information concerning the relocation of SUPERMON64, CBUS I switch settings and their effects. Also, more detail is presented as to the various memory configurations, memory maps and effects of the 6510 control port. As a bonus, the latest issue of CBUSter is included. This newsletter describes the exact modifications required to store certain cartridges onto disk and get them running.

2. Theory of operation

The Commodore 64 is a very powerful and flexible microcomputer. It has 20 Kbytes of ROM (Read Only Memory) overlayed on top of 64 Kbytes of RAM (Random Access Memory, also known as Read/Write Memory). The Commodore 64 also has a number of I/O (Input/Output) devices which include the VIC (Video Interface Controller), SID (Sound Interface Device, a true sound synthesizer), 2 CIAs (Complex Interface Adapters) and lastly, a PLA (Programmable Logic Array).

It is the PLA which gives the Commodore 64 its flexibility and versatility. By manipulating a group of sense lines into the PLA, the memory map of the Commodore 64 can be changed into a series of different organizations. There are two sense lines available for cartridge reorganization on the expansion bus, named GAME and EXROM. There are also two sense lines available internally, named LORAM and HIRAM. It is the selective activation (grounding, logic 0) of these four sense lines that determine the operating environment at any given time. Normally, GAME and EXROM float high (logic 1), and the microprocessor forces LORAM and HIRAM high. This configuration places the KERNAL (operating system) at the uppermost addresses (E000 to FFFF, note: all addresses and data bytes will be shown in their hexadecimal representation), BASIC in the middle (addresses A000 to BFFF) and RAM below that (addresses 0002 to 9FFF).

When a cartridge is plugged into the expansion port of the Commodore 64, the PLA changes the memory map into one of three configurations. When GAME is tied low, the ROM inside the cartridge replaces the KERNAL, and BASIC is deactivated. The 64 powers up, not as a Commodore 64, but rather as a dedicated machine executing the code inside the cartridge. When EXROM is tied low, the RAM located from 8000 to 9FFF is deactivated and the PLA allows the cartridge contents to take its place. If both EXROM and GAME are tied low, BASIC and the RAM located at addresses 8000 to 9FFF are deactivated and the PLA permits the microprocessor to access 16 Kbytes of cartridge ROM.

Whenever the Commodore 64 is turned on, one of two things happens. Either the KERNAL is replaced by a cartridge and the machine begins to execute the cartridge, or the KERNAL is activated and searches locations 8000 to 8008 for a particular sequences of numbers. If that sequence is correct, the KERNAL assumes a cartridge is present and begins execution of that cartridge. Otherwise, the KERNAL begins execution at the COLD start vectors found at A000 and A001.

Fortunately, it is the PLA and not the KERNAL which decides whether the KERNAL sees that particular code sequence externally (in a cartridge) or internally (in RAM). Therefore, if the proper sequence of bytes is present when the KERNAL begins its' search, the code in RAM will be executed in a fashion indistinguishable from that of a cartridge. Alternatively, if an image of a cartridge is placed in the RAM underneath the KERNAL (E000 to FFFF) and the KERNAL is switched off, the 64 will become a dedicated machine executing that code just as if a cartridge were in place.

The PLA permits cartridge emulation by manipulating the HIRAM and LORAM bits which are output lines of the 6510 microprocessor. LORAM permits BASIC to be swapped in or out as required, and HIRAM permits the KERNAL to be suppressed if necessary. The program DISK/CART-I takes advantage of these facts to produce the exact memory map required as described below.

3. Cartridge classification

a. Description

There are seven types of cartridges. The first two are fundamentally different from the other five and are referred to as G-types. The "G" indicates that the GAME sense line is used to replace the KERNAL. G2-types occupy two 4 Kbyte blocks for a total of 8 Kbytes and G4-types occupy 16 Kbytes. Both contain a ROM image that resides at locations E000 to FFFF. G4-types have an additional block that resides from 8000 to 9FFF.

The third, fourth and fifth kinds are all referred to as X-types since they primarily use the EXROM sense line to create an 8 Kbyte or 16 Kbyte hole in the C64's address space. X-types leave the KERNAL resident for access to various routines present there. X-types use the AUTOSTART sequence (see the next section) to begin execution.

X2-type cartridges occupy two 4 Kbyte blocks for a total of 8 Kbytes located at 8000 to 9FFF. X4-type cartridges occupy a total of 16 Kbytes and map onto addresses 8000 to BFFF and therefore overlay BASIC. When an X4-type cartridge is present, BASIC is removed by grounding the GAME sense line. When an X4-type image is used, BASIC is removed by setting LORAM low.

The other X-type cartridge is referred to as an XL-type. This is a 16 Kbyte ROM (8000 - BFFF) which requires some of the routines present in BASIC. Therefore, it requires a latch (hence the "L" of XL) to swap between the upper half (A000 - BFFF) of the cartridge and BASIC. In XL-type cartridges, there is actually a flip-flop which "remembers" whether BASIC or the upper half of the cartridge ROM is supposed to be present. In XL-type images, the LORAM bit is used for the same purpose.

The last two styles of cartridges are called the B-types. Here "B" refers to a BASIC replacement. The B-type cartridges do not contain the AUTOSTART sequence but rather provide an alternate COLD start vector at A000 and A001.

B2-types occupy 8 Kbytes from A000 to BFFF by grounding EXROM and GAME and then turning LORAM low to recover the RAM from 8000 to 9FFF. A B2-type cartridge image would already have this RAM available. B4-type cartridges occupy the same range as X4 types but do not contain the AUTOSTART sequence. B4 type images would be loaded in the same way as X4-type images but would be started using the COLD start vector at A000 and A001 rather than the AUTOSTART sequence.

b. Determining cartridge classification

It is a simple matter to determine a cartridge's classification. With the power off, carefully insert CBUS I into the expansion port of the Commodore 64. Set the DIPswitch to position AA by putting switches 1, 3, 5 and 7 to on and 2, 4, 6 and 8 to off. See Appendix b. for a further description of DIPswitch settings. This configuration allows all signals to pass through and should permit the cartridge under examination to perform normally. Insert the cartridge into the CBUS I connector so that the top of the cartridge faces you. Apply power to the C64 and confirm that the cartridge is operating normally. If not, turn power off and reseat CBUS I and the cartridge. Do not proceed until the cartridge operates normally with the DIPswitch in position AA.

Now turn all switches to off and flip switches 7 and 6 to on, yielding pattern 06. Press the RESET switch. If the cartridge operates normally, then it must be an X2 type. If this is the case, proceed to section 4 for taking a snapshot.

If the cartridge is not an X2-type, then turn switches 7 and 6 to off and flip switches 1 and 4 to on, yielding pattern 90. Press the RESET switch. If the cartridge operates normally, then it must be an G2-type. If this is the case, proceed to section 4 for taking a snapshot.

If the cartridge is neither an X2- or G2-type, then proceed with pattern 92. Press RESET. Normal operation indicates a G4-type cartridge. Pattern 94 confirms a B2-type.

If the cartridge is none of the above, then more work must be done to determine its classification. Normal operation under pattern 96 indicates either an X4- or B4-type cartridge. The only way to distinguish between these two types is to examine locations 8004 to 8008.

To do so, put the DIPswitch in position 04 and press RESET. This switch setting creates a "hole" at addresses 8000 to 9FFF. The power-on message should read 30719 BASIC BYTES FREE. Now load in either a machine language monitor such as SUPERMON64 or the MINI-MONITOR found on the CBUS deluxe disk. Once the monitor is operating, flip switch 7 on, yielding pattern 06. Now examine locations 8004 to 8008. A typical syntax might be:

M 8004 8008 [RETURN]

For the MINI-MONITOR, set the WINDOW starting at location 8000. If the following pattern (called the CBM80 autostart sequence)

is found, then the cartridge is an X4-type. Otherwise it is a B4-type.

Address	8004	8005	8006	8007	8008	
Data	C3	C2	CD	38	30	(indicates X4-type)

If the cartridge fails to operate properly for any of the above patterns (06, 90, 92, 94 or 96) then it must be an XL-type cartridge. This can be confirmed by putting the DIPswitch to pattern A6. This permits the GAME line to controlled by the cartridge itself, a necessity for XL-types.

If the cartridge still does not operate correctly, then go back and start again as any cartridge which operates correctly under pattern AA must work with one of the other 6 patterns.

To review, first confirm proper operation with the DIPswitch in pattern AA. Then set the DIPswitch to each of the following patterns and press RESET. Correct operation indicates the corresponding cartridge type. Except for distinguishing between X4- and B4-types, this is all that is necessary for classifying a given cartridge.

DIPswitch pattern	Cartridge classification
AA	all
06	X2
90	G2
92	G4
94	B2
96	X4 (CBM80) or B4 (no CBM80)
A6	XL

c. Summary of cartridge classifications

The following table summarizes the seven types of cartridges including their CBUS prefix, number of Kbytes, location where the code normally resides, location for disk loading and distinguishing characteristic. Note that the load address differs from the execution address only in the case of G-type cartridges.

Prefix	Kbytes	Exec. location	Load location	Features
G2	8	E000 to FFFF	2000 to 3FFF	Replaces KERNAL
G4	16	8000 to 9FFF	2000 to 3FFF	Replaces KERNAL
		E000 to FFFF	4000 to 5FFF	
X2	8	8000 to 9FFF	8000 to 9FFF	CBM80 autostart
X4	16	8000 to BFFF	8000 to BFFF	CBM80 autostart
XL	16	8000 to BFFF	8000 to BFFF	CBM80 autostart, hardware latch
B2	8	A000 to BFFF	A000 to BFFF	Replaces BASIC
B4	16	8000 to BFFF	8000 to BFFF	Replaces BASIC

4. Taking a snapshot of a cartridge

a. G2-types

G2-type cartridges normally reside from E000 to FFFF in place of the KERNAL. DISK/CART-I contains a small machine language loader that takes a G2 image residing from 2000 to 3FFF and POKEs it under the KERNAL then switches the KERNAL off. It then jumps to the cartridge RESET vector and execution begins. Therefore, all that has to be done with a G2-type cartridge is to copy the image to the range from 2000 to 3FFF.

To copy a G2-type cartridge, put the CBUS I DIPswitch into configuration 05. This maps the ROM normally found at E000 to FFFF down to 8000 - 9FFF. Using your monitor's transfer command, copy all bytes from 8000 - 9FFF to 2000 (- 3FFF). A typical syntax might be:

```
T 8000 9FFF 2000
```

To save this image to disk, use the save command, e.g.:

```
S "G2cartname",08,2000,4000
```

Note the ending address is one greater than expected. Most monitors save up to but not including the last location specified.

b. G4-types

G4-type cartridges consist of two halves. The lower half resides from 8000 to 9FFF and the upper half normally resides from E000 to FFFF in place of the KERNAL. DISK/CART-I requires that the image be loaded initially to locations 2000 - 5FFF. It will first POKE the lower half to 8000 - 9FFF. Then the upper half is POKEd under the KERNAL and then the KERNAL is switched off. DISK/CART-I then jumps to the cartridge RESET vector and execution begins. Therefore, a G4-type cartridge has to be copied in two halves to the range from 2000 to 5FFF.

If you are using an ML monitor such as SUPERMON64 then you can use the speed method for transfer. If you are using a BASIC monitor such as the MINI-MONITOR, then you must use the block procedure.

G4 SPEED METHOD: Put switch 6 to on (pattern 04), then flip switches 1, 4 and 7 (pattern 96). This maps the entire cartridge from the range 8000 to BFFF. Transfer down to 2000 using a syntax similar to:

```
T 8000 BFFF 2000
```

G4 BLOCK METHOD: Put the CBUS DIPswitch into configuration 06. This enables the lower half from locations 8000 to 9FFF. Transfer this range down to 2000, e.g.:

```
T 8000 9FFF 2000
```

Now change the DIPswitch to pattern 05. This maps the ROM normally found at E000 to FFFF down to 8000 - 9FFF. Copy this upper half to lower RAM using a syntax similar to:

```
T 8000 9FFF 4000
```

Whether you used the speed method or the two-step method, you will now have a 16 Kbyte image residing from 2000 to 5FFF. Save this image to disk using the save command, e.g.:

```
S "G4cartname",08,2000,6000
```

Note again that the ending address is one greater than expected.

c. X2-types

Saving an X2-type cartridge to disk is simplicity itself. Put the CBUS I DIPswitch to configuration 06 (activates ROM from 8000 to 9FFF) and save, e.g:

```
S "X2cartname",08,8000,A000
```

d. B2-types

If you are using an ML monitor, use the speed method. If you are using a BASIC type monitor such as the MINI-MONITOR, then use the block method.

B2 SPEED METHOD: Put the DIPswitch to pattern 96. This opens up the entire 16 Kbyte block from 8000 to BFFF, even though the cartridge only resides from A000 to BFFF. Now save to disk:

```
S "B2cartname",08,A000,C000
```

B2 BLOCK METHOD: Put the DIPswitch to pattern 05. This maps the ROM normally found from A000 to BFFF down to 8000 - 9FFF. Transfer the range from 8000 to 9FFF back to the RAM underneath BASIC, namely to A000 (to BFFF). Save the image from A000 to BFFF (remember to add an extra byte) using a B2 prefix.

e. X4-, B4- and XL-types

If you are using an ML monitor, use the speed method. If you are using a BASIC type monitor such as the MINI-MONITOR, then use the block method.

X4 SPEED METHOD: Put switch 6 to on (pattern 04), then flip switches 1, 4 and 7 (pattern 96). This maps the entire cartridge from the range 8000 to BFFF. Save the cartridge image to disk. For example:

```
S "X4cartname",08,8000,C000   for an X4-type or
S "B4cartname",08,8000,C000   for a B4-type or
S "XLcartname",08,8000,C000   for an XL-type.
```

X4 BLOCK METHOD: First put the DIPswitch to pattern 06. Transfer the bytes from 8000 to 9FFF down to 2000. Now flip switch 7 off and 8 on, yielding pattern 05. This remaps the upper ROM, normally residing from A000 to BFFF down to 8000 - 9FFF. Transfer this 8 Kbyte block down to 4000 - 5FFF. Flip switch 8 off again and transfer the entire 16 Kbyte block from locations 2000 - 5FFF to 8000 (- BFFF). Now save the range from 8000 to BFFF to disk using the appropriate prefix.

f. Summary

The following is a summary of the steps necessary to produce a snapshot of the various cartridge types.

G2-types:

1. Insert cartridge and confirm normal operation.
2. Put DIPswitch into configuration 05.
3. Transfer 8000 - 9FFF to 2000.
4. Save from 2000 to 3FFF(+1) using G2-prefix.

G4-types:

1. Insert cartridge and confirm normal operation.

G4 SPEED METHOD:
2. Put DIPswitch to pattern 96.
3. Transfer 8000 - BFFF to 2000.
4. Save from 2000 to 5FFF(+1) using G4-prefix.

G4 BLOCK METHOD:
2. Put DIPswitch to pattern 06.
3. Transfer from 8000 - 9FFF to 2000.
4. Put DIPswitch to pattern 05.
5. Transfer from 8000 - 9FFF to 4000.
6. Save from 2000 to 5FFF(+1) using G4-prefix.

X2-types:

1. Insert cartridge and confirm normal operation.
2. Put DIPswitch into configuration 06.
3. Save from 8000 to 9FFF(+1) using X2-prefix.

B2-types:

1. Insert cartridge and confirm normal operation.

B2 SPEED METHOD:
2. Put DIPswitch to pattern 96.
3. Save from A000 to BFFF(+1) using B2-prefix.

B2 BLOCK METHOD:
2. Put DIPswitch to pattern 05.
3. Transfer from 8000 - 9FFF to A000.
4. Save from A000 to BFFF(+1) using B2-prefix.

X4-, B4- and XL-types:

1. Insert cartridge and confirm normal operation.

X4 SPEED METHOD:
2. Put DIPswitch to pattern 96.
3. Save from 8000 to BFFF(+1) using the appropriate prefix

X4 BLOCK METHOD:
2. Put DIPswitch into configuration 06.
3. Transfer 8000 - 9FFF to 2000.
4. Put DIPswitch into configuration 05.
5. Transfer 8000 - 9FFF to 4000.
6. Put DIPswitch into configuration 04.
7. Transfer 2000 - 5FFF to 8000.
8. Save from 8000 to BFFF(+1) with appropriate prefix

5. A note to CBUS II users

If you are using CBUS I to make copies of cartridge images for use with CBUS II, then you should NOT make any changes to the cartridge images. This will interfere with proper operation. CBUS II eliminates the need for changing the cartridge image since it is a true cartridge emulator. Proceed with the instructions found in the CBUS II manual. Skip the next section or use it for informational purposes only.

6. Modifying snapshots to produce a loadable image

Many cartridges require no changes whatsoever. With the power off, remove the cartridge from CBUS I and set all switches to off. The RESET pushbutton is available to force a COLD start, if the machine hangs up. Load in DISK/CART-I but instead of typing RUN, type in RUN 100. This bypasses the normal directory lookup and allows direct entry of the cartridge name. Enter the name of the cartridge image to be tested. Be sure to include the CBUS prefix. If the cartridge loads and runs normally, add it to the directory by running MENGEN and that's it! Otherwise, see below.

a. G2-types

Of all the G2-type cartridges studied so far, 75% required no changes. Of the 25% remaining, all required the change of just one single byte. This is because DISK/CART-I loads the G2-image under the KERNAL then swaps the KERNAL out and begins execution. Certain programmers, following good, conservative programming practice, attempt to initialize all registers, including the one DISK/CART-I used to swap the KERNAL out. The result is the PLA tries to bring the KERNAL back in. When the cartridge is in place, this has no effect, since GAME is still grounded, but when the image is in RAM, it gets undone. Therefore, the byte used to reinitialize that register must be altered to leave the RAM image intact. Load the cartridge image back into locations 2000 - 3FFF and then use the hunt command.

Load the file in using (typical) monitor syntax:

```
L "G2cartname",08
```

Now hunt for the sequence STA 01 which translates to 85 01:

```
H 2000 3FFF 85 01
```

The monitor will return all addresses where this occurs. Say there is only one occurrance and it is at address 2066. Typically, if you disassemble the code from 2064 to 2067, you will see something like this:

```
;2064 A9 E7   LDA #$E7
;2066 85 01   STA $01
```

It would be a good idea to read the section entitled "Memory Management on the Commodore 64" in the Commodore 64 Programmer's Reference Guide (Copyright 1982 by Commodore Business Machines, Inc.) to see what the various bits in location 0001 do. In this case the E7 indicates that the programmer wanted to turn the KERNAL back on. Change this byte to E5 and then save the corrected image using a new name:

```
S "G2newcartname",08,2000,4000
```

When you have a working version of this cartridge, you can use the rename function (RO:) to change back to the old name.

Similarly, some programmers store a 37 into location 0001. If this is the case, change the 37 to a 35. Likewise, if a 33 is being stored, change this to a 31. The justification for these changes will be found in the Programmer's Reference Guide in the section on memory management. The following table summarizes what to change whenever the indicated sequences are found.

Old sequence	New sequence
A9 E7 85 01	A9 E5 85 01
A9 E3 85 01	A9 E1 85 01
A9 57 85 01	A9 55 85 01
A9 53 85 01	A9 51 85 01
A9 37 85 01	A9 35 85 01
A9 33 85 01	A9 31 85 01

Appendix e. summarizes the effects of these changes when both EXROM and GAME are high. Appendix c. shows all the possible organizations when all four sense bits are manipulated.

b. G4-types

G4-type cartridges are vulnerable to changes in location 0001 in the same way as G2-types. Therefore, the method and cure is the same as for G2-types. Follow the table shown above. Whenever the sequence on the left is found, change it to the sequence on the right.

c. X2-types

Of all the X2-type cartridges studied, only one was found to require any changes. In this particular case, the cartridge was a machine language monitor and the authors had an elaborate procedure for the program writing over itself. As long as the program resided in ROM, no harm was done. As soon as the image was transferred to RAM and run, the program destroyed itself. No further exploration was done on this particular cartridge.

d. B2-types

Since B2-types replace BASIC, you must guard against any attempt to bring the BASIC ROM set in. DISK/CART-I will set location 0001 to 56 to disable BASIC. When the code does not execute correctly, examine the cartridge image for the sequences and change accordingly:

Old sequence	New sequence
A9 E7 85 01	A9 E6 85 01
A9 57 85 01	A9 56 85 01
A9 37 85 01	A9 36 85 01

See Appendix e. for more details.

e. X4- and B4-types

Most of the 16 Kbyte cartridges studied required minor modifications. Two required no changes whatsoever. Another required a change identical to that described for G2-type cartridges. Specifically, there was a sequence that attempted to put a 57 into location 0001. When this byte was changed to a 55, everything worked fine. Another cartridge had a call to the KERNAL subroutine at FDA3 which disturbs location 0001. Changing the low byte of the call to FF (i.e. JSR FDA3 becomes JSR FDFF) eliminated this problem since FDFF is an RTS.

Other cartridges required more work. The concept of breakpoint programming is of particular use since RAM-based monitors do not allow real-time debugging of interrupt-driven programs. If a program does not work using DISK/CART-I, the procedure would be to reenter the monitor and load in the file manually, e.g.:

```
L "X4cartname",08 or
L "B4cartname",08
```

Once the file has been loaded, BASIC must be disabled by changing location 0001 from a 37 to a 36. The cartridge COLD Start vector is found at addresses 8000 and 8001 for X4-type cartridges and at A000 and A001 for B4-types. Take the example of an X4-type cartridge. Say the contents of locations 8000 and 8001 indicated a COLD Start at 8037. By inserting the command JMP 8037 at various points, the region where the image hangs up can be traced to a very small number of instructions. Another method might be to let the program hang up and then flip switch 6 on CBUS I to on. By hitting RESET, you can preserve the image and at the same time gain control of the 64.

After reentering the monitor, flip switch 6 off again, turn BASIC off by setting location 0001 to 36, and transfer the image from 8000 - BFFF to 2000. Then load in a fresh image of the cartridge and compare the two. Note: some monitors require BASIC to be present to do a load. In this case, turn BASIC on by putting a 37 into location 0001, load in the fresh image, then turn BASIC off again. Compare by using the (typical) syntax:

```
C 2000 5FFF 8000
```

The monitor will respond with all locations where the two images differ. This might yield some clue as to where the program is modifying itself. Sometimes this is intentional on the part of the author to foil such backup procedures. Other times it is a flaw in the program overlooked since ROMs can't be altered. In either case, breakpoint programming will eventually narrow down the offending code to just a few lines.

f. XL-types

The latch in XL-type cartridges is an integrated circuit. A software equivalent must be substituted for a RAM-based XL-type cartridge to succeed. Typically, the sequence 8D 00 DE is used to turn BASIC off, and the sequence AD 00 DE is used to turn BASIC on. The software equivalent would be to toggle the LORAM bit appropriately. Wherever these sequences appear, they must be altered to perform a JSR to a new toggle routine. A small section of the image is required to hold the new routine which consists simply of the following (say the code at 9F00 is available):

```
                                turn BASIC off
;9F00 48        PHA             save accum.
;9F01 A5 01     LDA #01         get control port image
;9F03 29 FE     AND #$FE        turn off LORAM
;9F05 85 01     STA #01         and BASIC is now off
;9F07 68        PLA             recover accum.
;9F08 60        RTS             and return

                                turn BASIC on
;9F00 48        PHA             save accum.
;9F01 A5 01     LDA #01         get control port image
;9F03 09 01     ORA #$01        turn on LORAM
;9F05 85 01     STA #01         and BASIC is now on
;9F07 68        PLA             recover accum.
;9F08 60        RTS             and return
```

If this doesn't solve it, again use breakpoint programming to pinpoint the code which causes the machine to hang up or the code to overwrite itself. Flipping the DIPswitch to pattern 04 then resetting the 64 will preserve the code at 8000 to 9FFF which can then be examined with a monitor when the DIPswitch is put back to position 00.

7. Using the two utility programs

The next section contains two listings. The first, MENGEN, creates a directory of cartridges for DISK/CART-I to load in. To create a directory for the first time, just run MENGEN. It will prompt you to insert the diskette containing the cartridge images. After this is done, just hit any key. To add a name to the directory for DISK/CART-I, just rerun MENGEN. It will perform the necessary bookkeeping functions automatically and then return control to BASIC. To load and run a cartridge-image from disk, use DISK/CART-I. It performs all necessary relocation and memory-map modifications. Use the [CRSR UP/DN] key or joystick (either port) until the desired selection is highlighted then press [RETURN] or hit the FIRE button. DISK/CART-I will automatically load and run the program desired. Please type in the programs and get them running before making any modifications.

The two program listings, MENGEN and DISK/CART-I were generated using a serial interface adapter. Therefore, instead of the Commodore symbols for cursor up/down, screen clear and the like, an abbreviation of the command such as <C/UP> or <CLR> is used, yielding somewhat more readable code. The following table provides a translation of some of the less obvious codes. Shown are the abbreviations and what to type. Where two keys are shown, both must be pressed simultaneously. For example, both the [CMDR] (Commodore) key and the 7 key must be pressed to produce the code for LBLU (light blue).

Abbrev.	Type		Abbrev.	Type
BLK	[CTRL]	1	C/UP	[SHIFT] [CRSR UP/DN]
WHT	[CTRL]	2	C/DN	[CRSR UP/DN]
BLUE	[CTRL]	7	C/LF	[SHIFT] [CRSR LEFT/RIGHT]
RVON	[CTRL]	9	C/RT	[CRSR LEFT/RIGHT]
RVOF	[CTRL]	0	CLR	[SHIFT] [CLR/HOME]
LGRN	[CMDR]	6	HOME	[CLR/HOME]
LBLU	[CMDR]	7		

8. PROGRAM LISTINGS

A. MENGEN V1.2

```
3 REM
40 REM    MENU GENERATOR (DIRECTORY)
50 REM    FOR DISK/CART-I AND CART/DISK-II
60 REM    R. J. BRACHMAN ASSOCIATES, INC.
70 REM    D. LEWIS, M. L. BRACHMAN, PH.D.
80 REM    MANY THANKS TO DON HUTTON
90 REM ------------------------------
100 REM
110 LN$="":FORI=1TO40:LN$=LN$+"─":NEXTI
120 LS$="":FORI=1TO40:LS$=LS$+" ":NEXTI
130 DIM TB$(100)
140 PRINT "(CLR)(BLUE)";:POKE53280,14:POKE53281,14
150 PRINTCHR$(142):PRINT"(RVON)(WHT)";LS$;
160 PRINT "(RVON)     R. J. BRACHMAN ASSOCIATES, INC.      ";
170 PRINT"(RVON)";LS$
180 PRINT"        C B U S     MENU GENERATOR"
190 PRINT"(BLUE)";LN$:PRINT
210 PRINT "INSERT DISKETTE THAT REQUIRES NEW MENU"
220 PRINT:PRINT"          HIT ANY KEY WHEN READY ";
240 REM PUTS UP BLINKING BLOCK AND GETS ONE CHARACTER
250 POKE198,0:PRINT "(WHT)(RVON) (C/LF)";
255 FOR I=1TO50:GETA$:IFA$<>""THEN285
260 NEXT I
265 PRINT "(RVOF) (C/LF)";
270 FOR I=1TO40:GETA$:IFA$<>""THEN285
280 NEXTI:GOTO250
285 PRINT "(RVOF) (C/LF)(BLUE)":PRINT:PRINTLN$
300 PRINT"          READING DIRECTORY ":DI=8
310 OPEN8,DI,0,"$0":FORC=1TO8:GET#8,A$:NEXT:C=1:DN$="":FORC=1TO16
320 GET#8,A$:DN$=DN$+A$:NEXT:GET#8,A$:GET#8,A$:DN$=DN$+"  ":GET#8,A$
330 DN$=DN$+A$:GET#8,A$:DN$=DN$+A$:GET#8,A$:GET#8,A$:DN$=DN$+"  "+A$
340 GET#8,A$:DN$=DN$+A$:GET#8,A$:C=1
350 FORA=1TO4:GET#8,A$:NEXT:PN$="":TY$=""
360 GET#8,A$:IFST<>0THEN450
370 IFA$=""THEN450
380 IFASC(A$)<>34THEN360
390 GET#8,A$:IFASC(A$)<>34THENPN$=PN$+A$:GOTO390
400 GET#8,A$:IFASC(A$)=32THEN400
410 TY$=TY$+A$:GET#8,A$:IFA$<>""THEN410
420 IFLEFT$(TY$,3)<>"PRG"THEN350
430 IFLEFT$(PN$,1)=" "THEN350
440 TB$(C)=PN$:C=C+1:IFST=0THEN350
450 CLOSE8:OPEN15,DI,15,"S0:   DIRECTORY   ":CLOSE15
455 PRINT:PRINT "          WRITING DIRECTORY(BLUE)"
460 Z$="◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆":OPEN8,DI,8,":   DIRECTORY   ,S,W":PRINT#8,DN$
470 FORA=1TOC-1:C$=Z$:FORB=1TOC-1
475 IF RIGHT$(C$,LEN(C$)-2)<RIGHT$(TB$(B),LEN(TB$(B))-2) THEN 490
480 C$=TB$(B):D=B
490 NEXT
500 PRINT#8,C$:TB$(D)=Z$:NEXT:CLOSE8
520 PRINT                                                    "
530 PRINT "(RVON)(WHT)          NEW MENU GENERATED!
540 PRINT"(LBLU)":POKE53281,6:END
```

B. DISK/CART-I V2.1

```
3 REM
10 REM  CBUS I CARTRIDGE LOADER PROGRAM
20 REM  R. J. BRACHMAN ASSOCIATES, INC.
30 REM  AUTHOR: M. L. BRACHMAN, PH.D.
40 REM  MANY THANKS TO: DON LEWIS
50 REM  AND DON HUTTON
60 REM ------------------------------
61 REM
65 POKE56,16:IFGF=0THEN550
70 FOR J=1TO1000:NEXTJ:PRINTTAB(28);"(LGRN)(C/UP)(RVON) OK (RVOF)"
71 FOR J=1TO1000:NEXTJ:REM TIME-OUT
75 CLOSE15
80 IF GF=1 OR GF=2 THEN 270
85 IF GF=3 THEN SYS64738
90 IF GF>=4 THEN 440
100 REM ------------------------------
105 REM
110 REM MANUAL LOAD OPTION
120 REM BYPASSES NEED TO GENERATE MENU
130 REM
140 POKE 53280,14:POKE 53281,14:PRINT"(BLUE)"
145 GOSUB 1100
150 PRINT "(CLR)(RVON) CBUS I  CARTRIDGE LOAD AND RUN (RVOF)"
155 PRINT
160 PRINT "NAME:";
165 INPUT C$:PRINT:PRINT"(C/UP)";
170 P$=LEFT$(C$,2)
175 C$=RIGHT$(C$,LEN(C$)-2)
180 REM ------------------------------
185 REM
190 REM SEARCH FOR LEGAL CART TYPE
195 FOR I=1 TO 7
200 IF P$=CN$(I) THEN 230
210 NEXT I
215 PRINT:PRINT "CBUS PREFIX MISSING!"
220 STOP
225 REM ------------------------------
230 REM
235 REM CBUS PREFIX OK!
240 GF=I
245 LOAD P$+C$,8,1
250 REM ------------------------------
255 REM
260 REM NORMAL G-TYPE LOADER HERE
270 NB=828
275 FOR J=0 TO 51
280 READ K
285 POKE NB+J,K
290 NEXT J
300 IF GF=1 THEN POKE 835,32
375 SYS NB:REM  TRANSFER AND RUN
380 DATA 169,00,133,02,133,04,169,64
385 DATA 160,224,133,03,132,05,162,31
```

```
390 DATA 160,00,177,02,145,04,200,208
395 DATA 249,230,03,230,05,202,16,240
400 DATA 165,03,201,96,208,06,169,32
405 DATA 160,128,208,222,120,169,5,133
410 DATA 1,108,252,255
420 REM ------------------------------
425 REM
430 REM X4,XL,B2,B4 LOADER
435 REM
440 FOR J=0 TO 51:READK:NEXT
445 REM
450 NB=828:REM  ML KERNAL-KOPY FOR 16 KBYTE AND B2-TYPES
460 FOR J=0 TO 30:READK
465 POKE NB+J,K:NEXT J
470 IF GF=6 OR GF=7 THEN POKE 858,160
480 REM
500 SYS NB:REM  EXECUTE KERNAL-KOPY AND RUN
510 DATA 169,00,133,02,169,224,133,03
520 DATA 160,00,177,02,145,02,200
530 DATA 208,249,230,03,208,245,169,229
540 DATA 141,214,253,133,01,108,00,128
544 REM
545 REM ------------------------------
546 REM
550 REM  LOAD IN DIRECTORY FOR MENU
555 REM
560 POKE53280,14:POKE53281,14:DIMTB$(80):PRINT"(CLR)(BLUE)":C=1
565 GOSUB 1100
570 OPEN8,8,8,":    DIRECTORY    ":OPEN15,8,15:INPUT#15,EC$,EM$,T$,S$
580 INPUT#8,DN$:IFEC$<>"00"THENCLOSE8:CLOSE15:GOTO 900
590 INPUT#8,TB$(C)
595 IF ST=66 THEN 640
600 IFASC(LEFT$(TB$(C),1))=1OTHENTB$(C)=RIGHT$(TB$(C),LEN(TB$(C))-1):GOTO 600
605 Z$=LEFT$(TB$(C),2)
608 REM
610 REM ------------------------------
611 REM
615 REM  ONLY SHOW CBUS PREFIXED FILES
620 FOR I=1TO7:IFZ$=CN$(I) THEN 630
625 NEXT I:GOTO 590
630 C=C+1:GOTO 590
635 CLOSE8:CLOSE15:M=C-1:TB$(C)=""
640 D=C-1:POKE198,0:REM CLEAR KBD BUFFER
645 PRINT "(WHT)CBUS I  CARTRIDGE LOADER  (RVON) VOLUME 1 (RVOF)(BLUE)":PRINT
650 DP$="(HOME)(C/DN)(C/DN)(C/DN)(C/DN)(C/DN)(C/DN)(C/DN)(C/DN)(C/DN)(C/
)(C/DN)(C/DN)(C/DN)(C/DN)(C/DN)(C/DN)(C/DN)"
655 FOR LP=1 TO D
660 GOSUB 920:REM PRINT NORMAL NAME
665 NEXT:PRINT
670 PRINT "(BLK)(RVON)  CRSR  (RVOF)(WHT) OR JOYSTICK SELECTS":PRINT
675 PRINT "(BLK)(RVON) RETURN (RVOF)(WHT) OR FIRE BUTTON LOADS";
680 PRINT "(BLUE)"
685 LP=1
690 GOSUB 950:REM PRINT REVERSE NAME
694 REM ------------------------------
```

```
695 REM
700 REM CHECK PORT 1, PORT 2 AND KEYBOARD
705 M=PEEK(56321)AND19:REM PORT1
710 IF M=19 THEN 735
715 IF M=18 THEN A$=CHR$(145)
720 IF M=17 THEN A$=CHR$(17)
725 IF M< 4 THEN A$=CHR$(13)
730 GOTO 785
735 M=PEEK(56320)AND19:REM PORT2
740 IF M=19 THEN 770
745 IF M=18 THEN A$=CHR$(145)
750 IF M=17 THEN A$=CHR$(17)
755 IF M< 4 THEN A$=CHR$(13)
760 GOTO 785
770 REM KEYBOARD ENTRY LAST
780 GET A$:IF A$="" THEN 705
785 K=ASC(A$)
790 IF K<>17 AND K<>145 AND K<>13 THEN 705
795 IF K=13 THEN GOTO 820
800 GOSUB 920:REM REPRINT NORMAL
805 IF K=17 THEN LP=LP+1:IF LP>D THEN LP=1
810 IF K=145 THEN LP=LP-1:IF LP<1 THEN LP=D
815 GOTO 690
820 PRINT LEFT$(DP$,LP+3);"(RVON)  LOADING"
830 G=LP
840 C$=RIGHT$(TB$(G),LEN(TB$(G))-2)
850 P$=LEFT$(TB$(G),2)
860 FOR I=1TO7:IFP$=CN$(I) THEN 880
870 NEXT I
875 PRINT "ILLEGAL PREFIX":STOP
880 GF=I
890 GOTO 245
900 PRINT "NO DIRECTORY, USE MENGEN"
910 STOP
920 REM SUB PRINTS NORMAL NAME
930 NO$=" "
940 GOTO 970
950 REM SUB PRINTS REVERSED NAME
960 NO$="(RVON) "
970 PRINT LEFT$(DP$,LP+3);
980 GL$=RIGHT$(TB$(LP),LEN(TB$(LP))-2)
990 GL$=GL$+" "
1000 PRINT "          ";NO$;GL$
1010 RETURN
1030 END
1100 DIM CN$(7):REM SET UP CART TYPES
1110 CN$(1)="G2"
1120 CN$(2)="G4"
1130 CN$(3)="X2"
1140 CN$(4)="X4"
1150 CN$(5)="XL"
1160 CN$(6)="B2"
1170 CN$(7)="B4"
1180 RETURN
6000 SAVE "@0:BDISK/CART-I",8
```

Appendix

a. Relocating SUPERMON64

SUPERMON64 is a machine language monitor for the Commodore 64. SUPERMON64 was written by Jim Butterfield and originally appeared in COMPUTE!, January, 1983, pgs. 162-169. Corrections and comments appeared in COMPUTE!, March, 1983, pg. 268 and COMPUTE!, June, 1983, pgs. 185-186. SUPERMON64 is also available on the Commodore BONUS DISK.

SUPERMON64 is a relocatable program. It builds itself from the top of user memory down. Normally, this means that SUPERMON64 exists from 97ED to 9FFF. While this is fine for most applications, it is not suitable for CBUS activities. More convenient locations would be from 77ED to 7FFF or C7ED to CFFF. SUPERMON64 located at the latter addresses is especially useful, since the RAM from C000 to CFFF is unavailable to BASIC. Described below is a method for relocating SUPERMON64 to either address range. This description refers specifically to the version supplied on the BONUS DISK, but should work with the version from COMPUTE!.

To relocate SUPERMON64 to C7ED-CFFF, type the following:

1. LOAD "SUPERMON64.V1",8 [RETURN]
2. POKE 55,0:POKE 56,208 [RETURN]
3. RUN [RETURN]

SUPERMON64 will be constructed at C7ED to CFFF. Then the SUPERMON64 log-on message and the SUPERMON64 prompt will appear. Now use SUPERMON64 to save a copy of itself to disk using the following:

4. S "SMON64.51181",08,C7ED,D000 [RETURN]

To load and use the relocated SUPERMON64, just:

5. LOAD "SMON64.51181",8,1 [RETURN]
6. SYS 51181 [RETURN]

The following steps will create a SUPERMON64 at 77ED to 7FFF:

1. LOAD "SUPERMON64.V1",8 [RETURN]
2. POKE 55,0:POKE 56,128 [RETURN]
3. RUN [RETURN]

4. S "SMON64.30701",08,77ED,8000 [RETURN]

5. LOAD "SMON64.30701",8,1 [RETURN]
6. POKE 55,0:POKE 56,119:SYS 30701 [RETURN]

b. Switch settings for the various cartridge types

CBUS I uses a DIPswitch to connect the various sense lines of the Commodore 64 to the following signals on the cartridge:

Switch position	1	2	3	4	5	6	7	8
Expansion bus	ROMH	ROMH	GAME	GAME	EXROM	EXROM	ROML	ROML
Cartridge	ROMH	n.c.	GAME	GND	EXROM	GND	ROML	ROMH

If the switches are viewed as an 8-bit binary number, then the hexadecimal equivalent provides a convenient notation for the various switch combinations, i.e.:

Binary weighting	128	64	32	16	8	4	2	1
Switch position	1	2	3	4	5	6	7	8

The following chart shows the typical switch combinations, their hex notation, their effect, and cartridge confirmation:

Hex Notation	Confirms Cart. Type	Effect	Switch Position 12345678
AA		Normal, pass through, for testing cartridge seating and function	x x x x o o o o
00		All lines disconnected, cartridge completely disabled	oooooooo
04		Disables cartridge, creates hole at 8000 - 9FFF	x ooooo oo
05		Maps G2 (normal E000 - FFFF) or upper half of X4 or XL (normal A000 - BFFF) to 8000 - 9FFF	x x ooooo o
06	X2	Forces EXROM to ground and activation at 8000 - 9FFF only, lower half of X4 or XL also	xx ooooo o
90	G2	Forces GAME to ground and allows activation at E000 - FFFF only	x x oo oooo
92	G4	Forces GAME to ground and allows both 8000 - 9FFF and E000 - FFFF	x x x oo oo o
94	B2	Grounds EXROM and GAME and allows activation A000 - BFFF only	x x x oo o oo
96	X4, B4	Grounds EXROM and GAME and allows activation from 8000 - BFFF	x x xx oo o o
A6	XL	Forces EXROM to ground but allows cartridge to control GAME	x x xx o oo o

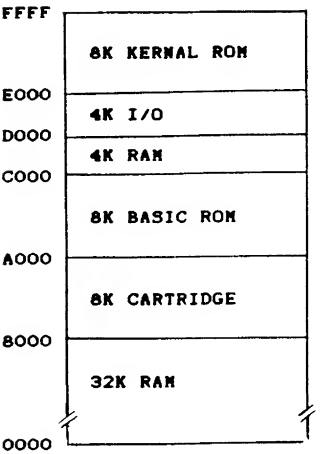
c. Commodore 64 memory configuration

The following table summarizes all the possible memory configurations using the two external sense lines, EXROM and GAME and the two memory bits, LORAM and HIRAM. Where appropriate, the cartridge type is noted.

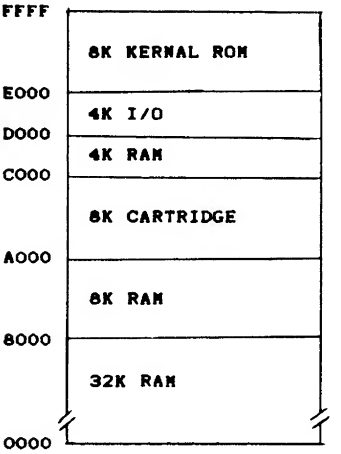
HIRAM	LORAM	EXROM	GAME	Cartridge	Features
1	1	1	1	--	Default map KERNAL, BASIC, 40 K RAM
1	1	1	0	G2, G4	"ULTIMAX" map No KERNAL or BASIC, 32 K RAM
1	1	0	1	X2, XLb	Standard cartridge map KERNAL, BASIC, 32 K RAM
1	1	0	0	X4, XLc, B4	Large cartridge map KERNAL, no BASIC, 32 K RAM
1	0	1	1	--	ML or CP/M map KERNAL, no BASIC, 52 K RAM
1	0	1	0	G2, G4	"ULTIMAX" map No KERNAL or BASIC, 32 K RAM
1	0	0	1	--	ML or CP/M map KERNAL, no BASIC, 52 K RAM
1	0	0	0	B2	BASIC replacement KERNAL, no BASIC, 40 K RAM
0	1	1	1	--	New KERNAL map RAM at top, 52 K RAM
0	1	1	0	G2, G4	"ULTIMAX" map No KERNAL or BASIC, 32 K RAM
0	1	0	1	--	New KERNAL map RAM at top, 52 K RAM
0	1	0	0	--	No character ROM map RAM at top, 52 K RAM
0	0	1	1	--	64 Kbytes of contiguous RAM No KERNAL or BASIC
0	0	1	0	G2, G4	"ULTIMAX" map No KERNAL or BASIC, 32 K RAM
0	0	0	1	--	64 Kbytes of contiguous RAM No KERNAL or BASIC
0	0	0	0	--	64 Kbytes of contiguous RAM No KERNAL or BASIC

d. Memory maps for the various cartridge types

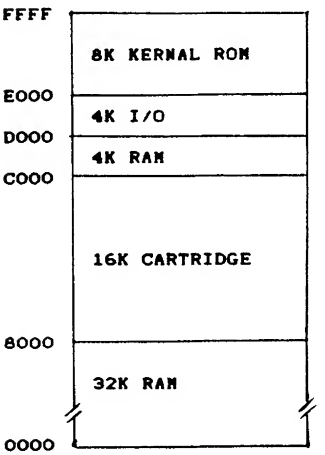
X2-, XLb-types



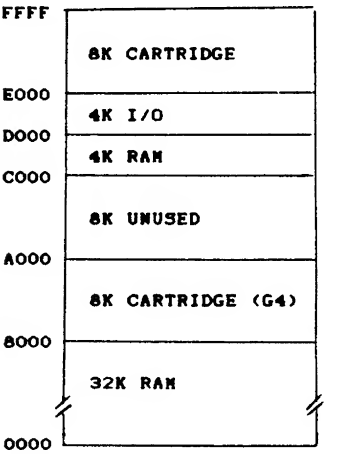
B2-types



X4, B4, XLc-types



G2, G4-types



Note: XL-types can swap the upper 8 Kbytes of ROM with BASIC. When the upper 8 K of the cartridge is activated, it is called the XLc configuration. When BASIC is swapped in, it is referred to as the XLb configuration.

e. Manipulating the 6510 control port

The table below shows the various combinations possible for the 6510 control port, located at memory address 0001. Only the first three bits are important in terms of memory management. Typical values for location 0001 are X7, X5 or X3 where X is typically 3, 5 or E.

Bit Patterns and Effect for 64 Memory Management (port 0001)

weight	4	2	1		
Bit	2	1	0	Typical Game Value	Effect
	0	0	0	E0, 50	BASIC out, KERNAL out, Char. ROM in
	0	0	1	E1, 51	BASIC out, KERNAL out, Char. ROM in
	0	1	0	E2, 52	BASIC out, KERNAL in, Char. ROM in
	0	1	1	E3, 53	BASIC in, KERNAL in, Char. ROM in
	1	0	0	E4, 54	BASIC out, KERNAL out, I/O in
	1	0	1	E5, 55	BASIC out, KERNAL out, I/O in
	1	1	0	E6, 56	BASIC out, KERNAL in, I/O in
	1	1	1	E7, 57	BASIC in, KERNAL in, I/O in

Note: this table assumes that EXROM and GAME are high

To create an executable cartridge image that can be loaded and run throught DISK/CART-I, you must be certain that BASIC is switched off by storing the appropriate value in location 0001. Use the hunt command to search for all occurences of the instruction STA 01 (85 01). Then change the data appropriately. For example, you might see in disassembly:

```
;2049  LDA  #$57
;204B  STA  $01
```

This code would turn BASIC and the KERNAL on. Change the 57 to a 55 to prevent this. In general, the following changes are suggested:

Change 57 or 56 to a 55
Change 53 or 52 to a 51
Leave 54 and 50 alone

More information on specific cartridges is contained in the CBUSter.

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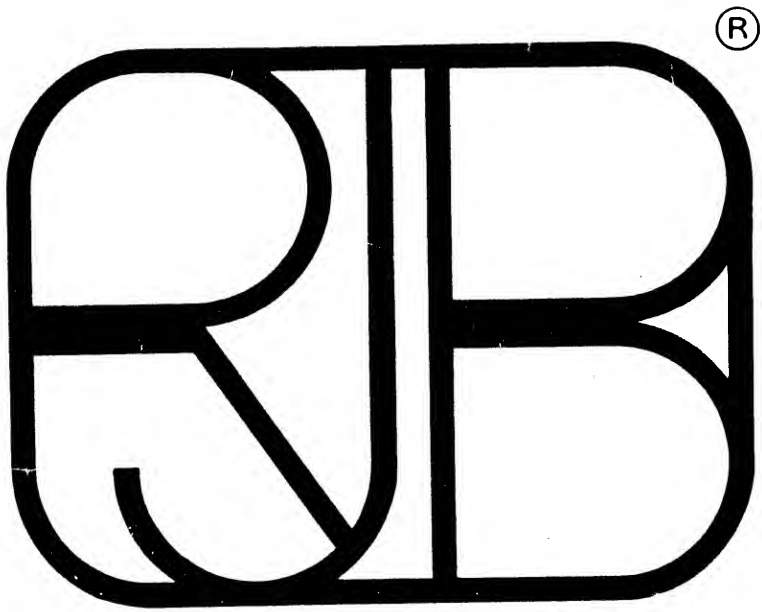
NOTES



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P. O. BOX 1077 - HAVERTOWN, PENNSYLVANIA 19083 (215) 622-5495

C B U S I

Cartridge Back Up System
for the Commodore 64

Cartridge Image Snapshooter

User Manual

MICROSPORT* COMPUTER PRODUCTS

R. J. BRACHMAN ASSOCIATES, INC.

P.O. BOX 579, HUNTINGDON VALLEY, PA 19006 215-357-5499

INSTRUCTIONS FOR USING THE CBUS SOURCE DISK
MINI-MONITOR V1.7

To [illegible] running the MINI-MONITOR, type in the following:

LOAD "MINIMON",8, [SHIFT RUN/STOP]

[SHIFT RUN/STOP] means press the [SHIFT] key and then press the [RUN/STOP] key. This will load in a small program which will change the screen color to a light blue and then indicate that it is loading the MINI-MONITOR. This takes about 1 minute. The screen will show the command summary lines at the bottom and then display the contents of 12 consecutive bytes starting at location 8000. This display is called the window (see the WINDOW command below). The prompt for a command will appear. Note: all commands can be aborted prior to execution by hitting the back-arrow [←]. Commands available are:

A ALTER — Allows you to change any byte in memory. The MINI-MONITOR will prompt for the address to be altered, then the data. Terminate entries using [RETURN]. Enter up to four hex digits for the address and two for the data. If no address is entered, the previous entry + 1 is used.

B [illegible] — Used to start an X4-, XL-, B2- or B4-type cartridge. You will be prompted for the start address. This is found at 8000 and 8001 for the X-types and A000 and A001 for the B-types. This command turns BASIC off and jumps to the address entered. Please note that the MINI-MONITOR cannot be reentered once this command is executed. Use this command only after a copy of the object code being tested has been saved. Answer with a "Y" to begin or type "N" or [←] to abort.

S [illegible] — Used to start an X2-type cartridge. You will be asked "ARE YOU SURE?" Answer with a "Y" to begin or an "N" or [←] to abort. A COLD START is performed and the KERNAL will automatically fetch the COLD START vectors from 8000 and 8001. Once again, the MINI-MONITOR cannot be reentered once this command is executed so be certain a copy has been saved to disk.

to copy the image first to 4000 - 5FFF and then to the RAM underneath BASIC itself. Now SAVE from 4000 to C000 using the B2 prefix (e.g. B2GAMES).

XL-types: To take a snapshot of an XL-type cartridge, first put the DIPswitch into pattern 06. Now use the X command to transfer the image from its normal locations at 8000 - BFFF down to 2000 - 3FFF. Now change the DIPswitch to pattern 05. Use the T command to transfer the image just carefully rescued from 8000 - BFFF down to 4000 - 5FFF. Now, whether the complete image back to its normal locations with the T command. SAVE from 8000 to C000 using XL prefix (e.g. XLGAMES).

The tests described in the CBUG I manual cannot distinguish between a B4- and an X4-type cartridge. When you have determined that a given cartridge is one of the two types, the following procedure to distinguish between them.

Put the DIPswitch into pattern 06 and use the X8000 command to examine locations 8000 to 8005. An X4-type cartridge will have the following pattern. A B4-type cartridge will not.

ADDRESS	8000	8001	8002	8003	8004	8005
DATA	C3	32	3F	38	30	

If this pattern is present, use the X4 prefix when saving to disk, if not, then use the B4 prefix. Otherwise, the procedure for taking a snapshot is the same.

X4- and B4-types: Put the DIPswitch into pattern 05. Use the X command to copy the lower half down to 2000 - 3FFF. Now put the DIPswitch in position 05. Use the T command to transfer the upper half down to 4000 - 5FFF. Now use the T command to transfer the entire 16 Kbyte image back to the RAM from 8000 to BFFF. SAVE from 8000 to C000 using the X4 or B4 prefix, whichever is appropriate. Remember, do NOT turn BASIC off as described in the manual!

If the cartridge requires modification, move the cartridge image down to addresses 2000 - 3FFF (or 2000 - 5FFF or 4000 - 5FFF whichever is appropriate) as you would when taking a snapshot. Then use the HUNT command to examine the block for the offending sequence of bytes. Use the ALTER command to change as required, then transfer back using either the Y or Z commands as described in the section on taking a snapshot. SAVE the newly modified code under a new name until it works then scratch the original version and rename the corrected file.

Programmer's note: the COMMAND interpreter and display portions of the MINI-MONITOR are in BASIC but the execution of the various commands is performed in machine language. The necessary code is POKE'd from DATA statements using a RESTORE then a FOR-NEXT loop to advance the pointer to the appropriate section. Please bear this in mind when making modifications to the MINI-MONITOR program itself. Simple changes such as screen color or formatting can be made with impunity; however, the various POKES should be considered inviolable.

G	BEGIN	Used to start a G2-type cartridge. You will be asked "ARE YOU SURE?". Answer with a "Y" to begin or an "N" or [←] to abort. The code from 2000 to 3FFF is POKEd underneath the KERNAL and then the KERNAL is turned off. A COLD START is performed and the RESET vector is fetched from locations FFFC and FFFD. Again, the MINI MONITOR cannot be reentered once this command is executed.
I	BEGIN	Used to start a G4-type cartridge. You will be asked "ARE YOU SURE?". Answer with a "Y" to begin or an "N" or [←] to abort. The code from 2000 to 3FFF is transferred to 8000 to 9FFF, then the code from 4000 to 5FFF is transferred to 2000 to 3FFF, then POKEd underneath the KERNAL and then the KERNAL is turned off. A COLD START is performed and the RESET vector is fetched from locations FFFC and FFFD. Again, the MINI MONITOR cannot be reentered once this command is executed.
C	COMP	Allows you to compare two ranges of memory. The MINI-MONITOR will ask for the start and ending address of the first block of memory and the starting address of the second block. It will then compare the two blocks on a byte-by-byte basis, halting whenever a mismatch occurs. Hit the space bar to continue the comparison or use [←] to abort.
F	FLOAT	This command does not appear in the command summary at the bottom of the screen. This command will print the contents of the entered location four times. If the contents change then a float condition most likely has occurred.
H	HUNT	Searches a block of memory for the occurrence of a sequence of bytes. First enter the range for the hunt to occur, then the number of bytes in the sequence. Then enter the actual data bytes themselves. The program will halt whenever a match occurs. Hit the space bar to continue or use [←] to abort.
L	LOAD	Loads in a block of object code from disk. Remember to use the CBUS prefix when specifying cartridge image.
S	SAVE	Saves a block of object code to disk. Enter the starting address then the ending address plus 1. For example, to save the block of code residing 8000 to 9FFF, you enter SAVE FROM 8000 TO A000. Then enter the file name, remembering to use one of the seven CBUS prefixes (G2, G4, X2, X4, X or B4) if this is to be used by DISK/CART-I or CART/DISK-II. Note: this command turns BASIC

prior to saving an image to disk. DO NOT DO SO YOURSELF! This will cause the MINI-MONITOR to hang up permanently!

W W ADDR Specify the first byte of the 12 byte block to be displayed.

T T TO 4) Transfers all bytes from 8000 - 9FFF inclusive to 4000 - 5FFF.

T T TO 2) Transfers all bytes from 8000 - 9FFF inclusive to 2000 - 3FFF.

T 2 4 Transfers all bytes from 2000 - 3FFF inclusive to 4000 - 5FFF.

T 2 6 Transfers all bytes from 2000 - 5FFF inclusive to 6000 - BFFF.

C CANCELS Aborts any command prior to execution and rewrites the window.

The MINI-MONITOR can be used to take snapshots of all the cartridge types, make small modifications and test those modifications, all from a BASIC environment. Below is a description of how to take a snapshot of each of the cartridge types.

G2 types: To take a snapshot of a G2-type cartridge for [illegible] CART I or CART/DISK-II, put the DIPswitch in position 05. [illegible] the Y command to transfer the image to 2000 then SAVE from [illegible] to 4000 using the G2 prefix. E.g. if the file is to be [illegible] GAME1 then use the name G2GAME1.

G4 types: To take a snapshot of a G4-type cartridge, you will [illegible] use the block method, described in the CBUS I manual. First put the DIPswitch in pattern 06. Use the X command to [illegible] the image from 8000 - 9FFF to 2000. Then put the [illegible] to pattern 05. Use the T command to transfer the [illegible] from 8000 - 9FFF (normally residing at E000 - FFFF) to [illegible]. Now SAVE from 2000 to 6000 using the G4 prefix. E.g. if the file is to be called GAME2, use the name G4GAME2.

X2 types: To take a snapshot of an X2-type cartridge, put the DIPswitch in pattern 06. Use the X command then the Y command to copy the image back onto itself. This is because the MINI-MONITOR turns BASIC off prior to saving to disk. One side effect of turning BASIC off is that an external cartridge image is ignored. Therefore, you must have a cartridge image [illegible] in the RAM underneath the cartridge from 8000 - 9FFF. [illegible] it from 8000 to A000 using the X2 prefix (e.g. X2GAME3).

B2 types: To take a snapshot of an B2-type cartridge, put the [illegible] switch in pattern 05. Use the T command then the Z command